Worked answers -

Centre No.						Paper Reference	Surname	Initial(s)
Candidate No.						1 6 2 7 / 0 1	Signature	

Paper Reference(s)

1627/01

Edexcel GCSE

Astronomy

Paper 01

Friday 15 May 2009 – Morning

Time: 2 hours

I hope that you find the detail useful.

Examiner's use only		

Team Leader's use only		

Materials required for examination	Items included with question papers
Calculator	Nil

Ladies and Gentlemen, Lots of "JF^2" material contained within...

Instructions to Candidates

In the boxes above, write your centre number, candidate number, your surname and initial(s) and your signature.
Answer ALL questions in the spaces provided in this book. Do not use pencil. Use blue or black ink.
Show all stages in any calculations and state the units. Calculators may be used.
Include diagrams in your answers where these are helpful.
Some questions must be answered with a cross in a box (☒). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☒).

Information for Candidates

~~The marks for the various parts of questions are shown in round brackets: e.g. (2).~~
There are 20 questions in this question paper. The total mark for this paper is 120.
There are 24 pages in this question paper. Any blank pages are indicated.

Advice to Candidates

This symbol shows where the quality of your written answer will also be assessed.

Question Number	Leave Blank
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Leave blank

1. (a) Which of the following is the largest? Put a cross (☒) in the correct box.

Earth ☒

Moon ☒

Sun ☒ ✓

(A tick photocopies better, but in the exam. you <u>must</u> use a cross.)

(1)

(b) What is the average distance from the Earth to the Sun? Put a cross (☒) in the correct box.

1 Astronomical Unit ☒ ✓

1 light year ☒

1 parsec ☒

(1)

(c) What is the approximate diameter of the Moon? Put a cross (☒) in the correct box.

2000 km ☒

3500 km ☒ ✓

5000 km ☒

10 000 km ☒

(d) What is the shape of the Earth's orbit around the Sun? Put a cross (☒) in the correct box.

a circle ☒

an ellipse ☒ ✓

a parabola ☒

a zodiacal band ☒

(1)

Q1

(Total 4 marks)

Leave blank

2. Five planets are listed below:

Mercury

Venus

Mars

Jupiter

Saturn

Name the planet that is being described in each statement (a) to (d) below.

(a) The surface is generally grey in colour and so highly cratered that it resembles the Moon.

Mercury

(b) The surface is generally red and its thin atmosphere contains traces of methane.

Mars

(c) It is usually only visible at dawn or dusk and its dense atmosphere is highly reflective.

Venus

(d) Through a small telescope, up to four satellites of this gas giant can be seen.

Jupiter

Q2

(Total 4 marks)

Turn over

Leave blank

3. (a) Which space mission mapped the surface of Venus using radar? Put a cross (☒) in the correct box.

Apollo 11 ☒

Giotto ☒

Magellan ☒ ✓

Voyager 1 ☒

(1)

(b) Which space mission studied Halley's Comet? Put a cross (☒) in the correct box.

Cassini ☒

Galileo ☒

Giotto ☒ ✓

Magellan ☒

(1)

(c) Describe briefly **two** of the problems that humans might experience in travelling to a planet.

① Muscle fatigue, ② brittle bones, ③ asteroid strikes ④ Radiation, ⑤ Space sickness, ⑥ Delays in communication, ⑦ Psychological problems (long-term)

⑧ Organising a rescue, if something goes wrong.

(2)

Q3

(Total 4 marks)

JF[2]

Possible psychological problems were hardly considered.

Leave blank

4. (a) What is the phase of the Moon during a lunar eclipse? Put a cross (☒) in the correct box.

crescent ☒

full ☒ ✓

gibbous ☒

new ☒

(1)

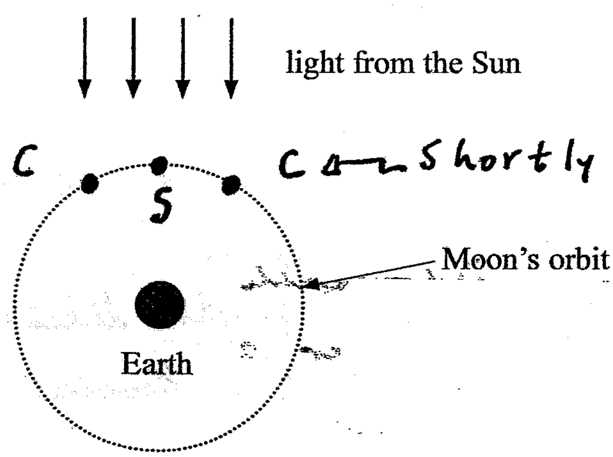
(b) State the phase of the Moon during a neap tide.

First / Last quarter

(1)

(c) The diagram (not to scale) shows the orbit of the Moon around the Earth and rays of light from the Sun.

Shortly after New Moon → C



C — Shortly before New Moon

On the diagram, indicate the position

(i) during a solar eclipse (use the letter S);

(ii) when the Moon would appear as a thin crescent from the Earth (use the letter C).

(2)

(d) As it orbits the Earth, the same side of the Moon always faces the Earth. State the reason for this.

(i) The rotational period of the Moon = Orbital period.
(ii) Captured orbit.
(iii) Synchronous rotation.
(iv) Tidal "locking"

} Any one of these

(2)

Q4

(Total 6 marks)

Turn over

Leave blank

5. (a) Who was credited with suggesting that planets orbit the Sun rather than the Earth? Put a cross (☒) in the correct box.

Copernicus ☒ ✓

Galileo ☒

Kepler ☒

Newton ☒

(1)

(b) Who used mathematics to explain the laws of planetary motion? Put a cross (☒) in the correct box.

Copernicus ☒

Galileo ☒

Kepler ☒

Newton ☒ ✓

Take care here: Kepler enunciated the laws, but it was Newton who explained them.

(1)

(c) In 1801 Ceres was the first asteroid to be discovered. In 1930 Pluto was discovered.

(i) State **two** similarities between Ceres and Pluto.

1 Spherical ③ Comparable diameter ④ Solid

2 orbit the Sun ④ Similar densities

⑤ No atmosphere.

(ii) State **two** differences between Ceres and Pluto.

1 Distances from the Sun

2 Nature | Brightness of the surfaces

③ Eccentricity of the orbits (Pluto has a very elliptical orbit)

(2)

(Total 6 marks)

Q5

④ Orbital inclinations to the plane of the Solar System.

JF[2] Pluto was discovered by Clyde Tombaugh at the Lowell Observatory.

G. Piazzi made the discovery of Ceres on January 1. One year later, H. W. M. Olbers discovered Pallas. (Both are about 2.8 A.U. from the Sun)

Leave blank

6. Just before sunrise a group of students were observing the sky. They noticed that Venus and a thin decrescent Moon were close to each other.

(a) In which direction were the students looking?

East or South East } To the "right" of the Sun

(1)

(b) Deduce the phase of Venus at this time.

Crescent

(1)

(c) One student noticed a faint band of light stretching across the sky.

(i) What is the name of this faint band? Put a cross (☒) in the correct box.

Ecliptic	☒
Kuiper Belt	☒
Milky Way	☒ ✓
Zodiacal Band	☒

In 1610

Actually, the explanation was not provided until many, many years later.

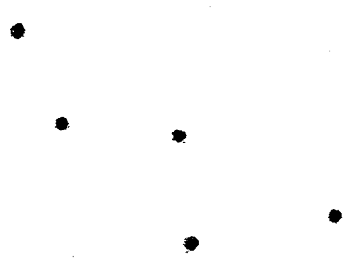
? **(1)**

(ii) Who was the first person to explain the nature of this faint band?

Thought to be Galileo : he certainly resolved the Milky Way into countless (individual) stars.

(1)

(d) The students observed the constellation Cassiopeia. Draw a sketch of this constellation.



JF[2] Cassiopeia revolves around Polaris, always opposite the Plough. Its position on a "clock face" depends on the time and the season. Both are circumpolar ∴ always visible on a clear night.

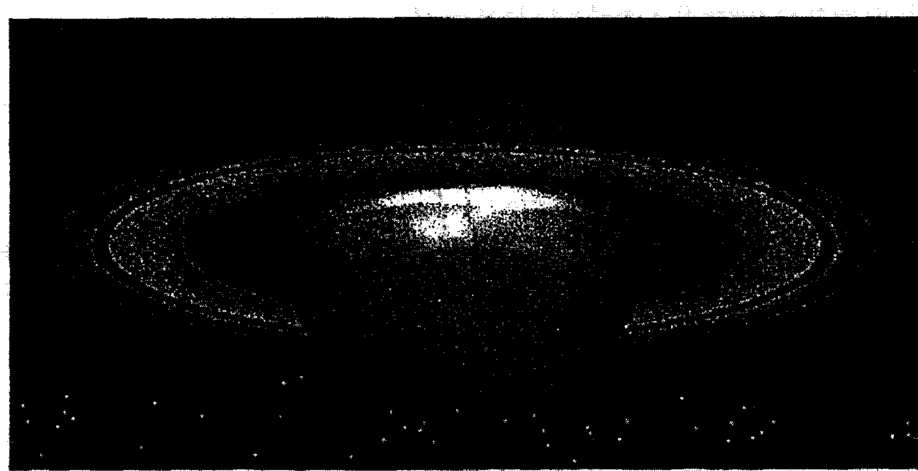
(1) Q6

(Total 5 marks)

JF[2] (6) (c) Galileo is credited with the first person to observe the Jovian moons (Io, Europa, Ganymede and Callisto) as well pointing his simple telescope at the Moon and the Milky Way →

In doing so, he incurred the wrath of the Catholic Church. His pardon took nearly four hundred years to be granted.

7. The photograph shows Saturn and its rings.



Around 20 miles, or so, thick

186 000 miles across

Image courtesy of NASA

(a) Describe the physical nature and composition of Saturn's rings.

① Millions of individual particles, each one obeying the third law of planetary motion ($T^2 \propto d^3$)
② Ice, ③ rock, ④ split into divisions, ⑤ closely connected with the satellites, ⑥ small thickness compared with the diameter.

(b) (i) At which point in its orbit is Saturn best observed from Earth? Put a cross (☒) in the correct box.

conjunction ☐

occultation ☐

opposition ☒ ✓

transit ☐

(ii) Give **three** reasons why Saturn is best observed at this point.

① Closest to the Earth.
② Opposite the Sun in the sky.
③ Visible for long periods during the night.
④ Brightest (depends on the orientation of the rings)
⑤ Best resolution (the ability to discern details).

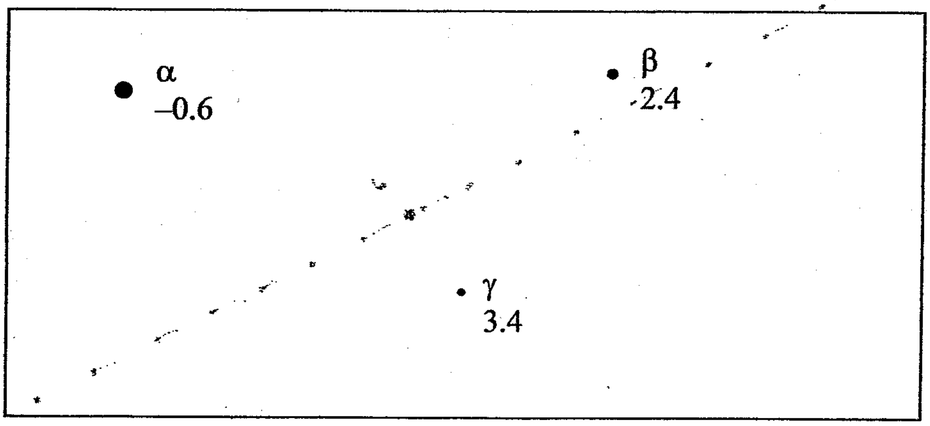
(3)

(Total 6 marks)

Q7

Leave blank

8. The diagram shows the three brightest stars in a constellation with their apparent magnitudes.



(a) (i) By how many times is β brighter than γ?

2·5

(1)

(ii) By how many times is α brighter than β?

$m_\alpha > m_\beta \Rightarrow \Delta m = 3\cdot0 \quad \therefore \quad \Delta B = (2\cdot5)^3 = 16$

(1)

*Please do not correct on your script!

(b) The two stars β and γ have the same absolute magnitude. State which star is ~~further~~ *farther away from the Earth. Give a reason for your answer.

Star γ

Reason Both β and γ would be equally bright at a distance of 10 pc. γ appears to be the fainter. So, it must be farther away.

(2)

(c) A fourth star η (not shown), is 250 times fainter than α. What is its magnitude?

$m_\eta = \left(\frac{1}{250}\right) \times m_\alpha \quad \therefore \quad 250 = (2\cdot5)^{\Delta m}$, where Δm = magnitude difference.

(1)

(Total 5 marks)

Q8

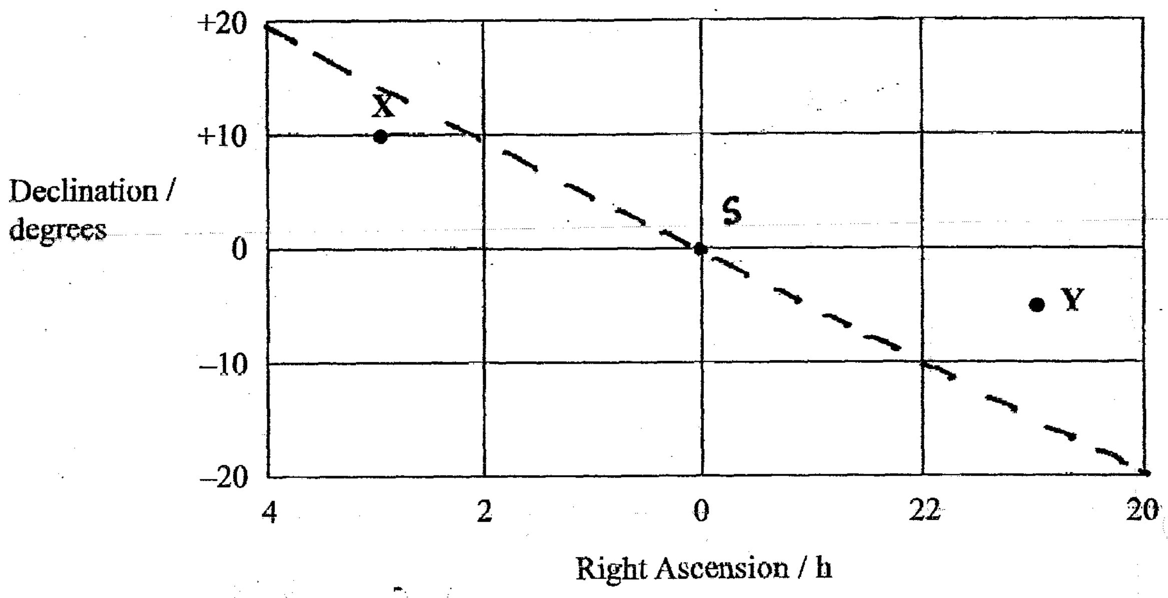
Simplifying:

$\log_{10} 250 = \Delta m \times \log_{10} 2\cdot5$

$\therefore \quad \Delta m = \frac{\log_{10} 250}{\log_{10} 2\cdot5} = 6 \quad \therefore m_\eta = 5\cdot4$

Turn over

9. The diagram shows part of the celestial sphere. Two stars, X and Y, are shown.



(a) State the Right Ascension of star X.

3 hours

(1)

(b) On the grid:

(i) S drawn at 0 hours and zero degrees

(ii) The line should be drawn from the top left to the bottom right, passing through 0 hor and zero degrees.

(c) The "First Point of Aries". (This is its historical name : the phenomenon of Precession has complicated the entire business —— please see later in class)

(d) 5° South

(10)

(a) The refraction of light (mainly from the Polar regions) through the atmosphere of the Earth)

(b) The sun emits electromagnetic radiation over the entire spectrum —— including the relatively narrow band which is referred to as the "visible" region.

The intensity of the yellowness is indicative of the temperature of the photosphere ~ 6000K.

JF[2]

Stars with a higher surface temperature produce more short - wave radiation, so their colours are shifted towards the white → blue regions of the visible spectrum (more energetic radiation) eg. Rigel in Orion ($T_{surface}$ ~ 20000K)

Those stars which are cooler at their surfaces, eg. Betelgeuse, produce light which has a peak in the red region (less energetic) of the spectrum (T ~ 3000K)

(c) There is no atmosphere

∴ no mechanism for scattering the light the light from the sun.

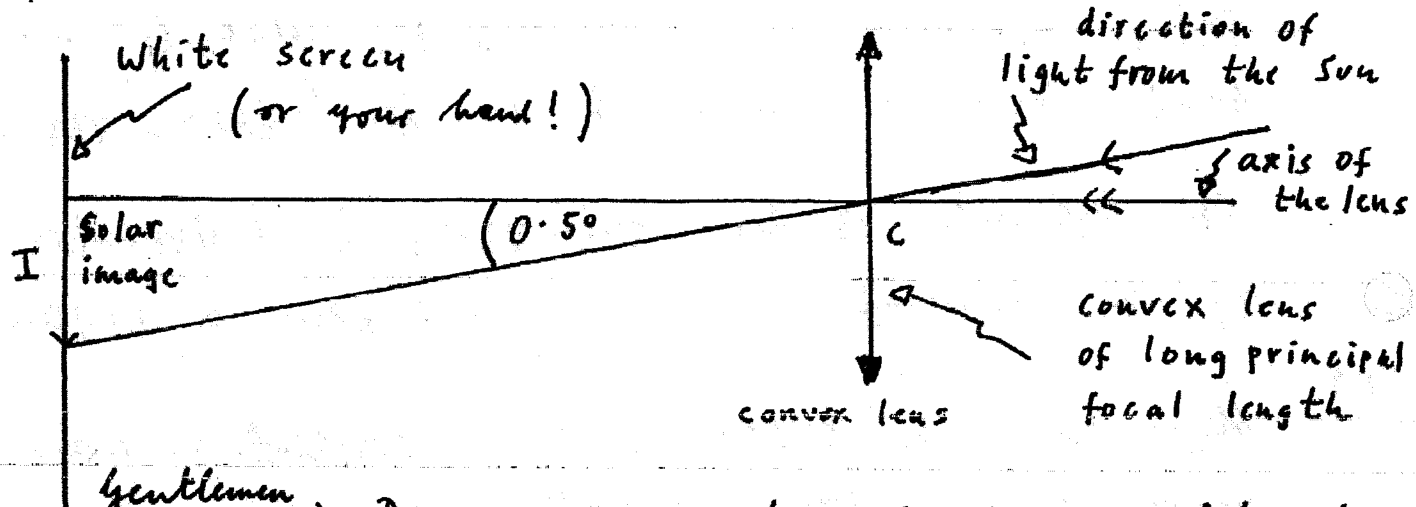
[However, lunar astronauts have referred to the glare from certain areas of the surface of the Moon — reducing the blackness of the lunar sky.]

Leave blank

11. (a) Explain why it is dangerous to observe the Sun directly.

The cornea (the principal refracting component) would focus both heat and light onto your retina (and simple) (2)

(b) (i) Describe one safe method of observing the Sun.



Gentlemen, Do you remember forming an intensely hot image of the Sun on a piece of white paper? The brave ones amongst you substituted their hands. I recall Matthew Hill's yelp... Remind me: did I undertake a risk assessment, apart from forbidding you to look directly at the Sun?

(ii) With a sufficiently large telescope:

(i) Sunspots, (ii) Solar flares, (iii) possibly the surface granulation and time-lapse photography for the prominences.
Certainly, the limb-darkening is clear on photographs

(c) (i) The corona can be observed
(ii) The X-ray spectrum can be detected (not "observed") as can the radio-wave regions.

(12)

(a) Problems:

(i) Difficult to repair, (ii) accessibility, (iii) could be struck by meteor(oids) or /and other space debris.

\+ other sensible suggestions.

Advantages:

(i) In space, above the atmosphere of the Earth, implying clear skies.

(ii) 24-hour observations, covering the skies above both hemispheres

(b) This is a huge question to answer, because you could make so many points.

(i) The main mirrors each requires only one optically perfect surface. The objective lens of the refractor requires both of its refracting surfaces to be optically perfect. Also, the refractive index throughout the lens must be constant (homogeneous refractive index)

(ii) A mirror does not suffer from chromatic aberration, whereas a lens does, and this must be corrected

(iii) Reflectors can be more difficult to maintain, because the secondary mirror requires adjustment

(iv) A mirror of greater aperture than a lens can be built ⇒ greater light-gathering power and resolution.

(c) (i) Area $\propto d^2$ $\therefore (4\cdot 5\,\mathrm{m})^2 : (1\cdot 5\,\mathrm{m})^2 = \underline{9:1}$

(ii) Greater resolution: a better ability to distinguish between two / three / etc. sources of light.

Leave blank

13. (a) Where are most asteroids located within our Solar System?

Between the orbits of Mars and Jupiter

(1)

(b) Asteroids are too faint to observe with the naked eye. Give **two** reasons why asteroids are faint.

1 Large distance, (2) small diameter,

(3) low albedo, implies that the surfaces are dark and of low reflectivity.

(2)

(c) There is an increasing concern that an asteroid will collide with the Earth at some point in the future. Describe **two** pieces of astronomical evidence to support this view.

1 The craters on the lunar surface.

(2) The collision of a comet with Jupiter.

(3) In 1908 a "large" meteorite landed in Siberia, causing immense damage.

(2)

(4) Perhaps the prograde rotation of Venus?

Q13

(Total 5 marks)

(5) The Arizona meteor crater.

(6) The axial tilt of Uranus.

JF²

Asteroid diameters have a size distribution quite similar to that of impact craters. Many planetary impact craters were produced by the impact of an asteroid. Asteroids are assigned different taxonomic classes, which are related to their composition and determined by astronomical observations.

These minor bodies in the Solar System undergo orbital evolution, such that over →

thousands and millions of years the orbits are changed significantly. Presumably, this is how so-called "Near Earth Asteroids" come from the asteroid belt by the mechanism of orbital evolution.

Ceres (pronounced "Series"), diameter 913 km.
Pallas, diameter 523 km.

As we go smaller and smaller, the asteroids become more numerous. There are seven larger than 300 km, eighty-one larger than 150 km.

Until relatively recently, what we knew about asteroids was based on ground observations. A small number* of spacecraft missions has come close to asteroids, allowing us to learn much more about these minor bodies.

* singular noun

The Galileo spacecraft, en route to Jupiter, flew by Gaspra, obtaining the first ever high-resolution image of an asteroid. A rather irregularly-shaped body, peppered with impact craters was seen. Galileo's second, much larger, asteroid target, Ida, showed similar features.

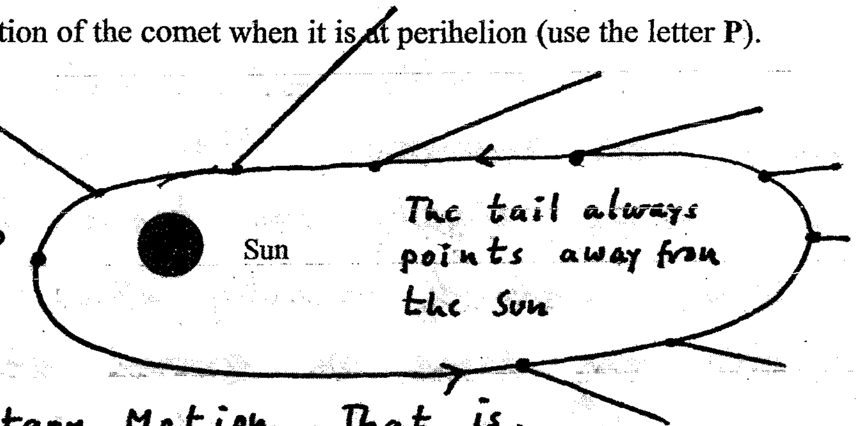
Asteroid	Spacecraft	Encounter date	Asteroid size (km)	
Gaspra	Galileo	1991, Oct. 29	19 x 12	Indicating an irregular shape.
Ida	Galileo	1993, Aug. 28	58 x 23	
Mathilde	NEAR	1997, June 27	59 x 47	
Eros	NEAR	2000, Feb. 14	33 x 13	
Braille	Deep Space 1	1999, July 29	2.2 x 1	
Annefrank	Stardust	2002, Nov. 2	8 x 4	

14. (a) Describe the location and nature of the Kuiper Belt. The region of the Solar System, beyond the orbit of Neptune (30 A.U.), containing many icy planetesimals and cometary nuclei. The region is named after G.P. Kuiper, in 1951. However, work by astronomers K.E. Edgeworth (1943) and F.C. Leonard (1930) also remarked on the likely existence of such a belt (Indeed, the belt is sometimes called the Edgeworth-Kuiper Belt). Thought to contain between 10^7 and 10^9 bodies. **(2)**

(b) On the diagram below:

(i) draw the complete orbit of a typical short-period comet;

(ii) indicate the position of the comet when it is at perihelion (use the letter P).



Remember that, throughout the motion of the comet, it obeys Kepler's Laws I and II of Planetary Motion. That is, the radius vector sweeps out equal areas of space during equal time intervals and $\frac{T^2}{d^3}$ is a constant **(3)**

(c) A short-period comet is 2.5 AU from the Sun at its closest point. The comet is 12.5 AU from the Sun at its furthest point. By how many times is the Sun's pull of gravity on the comet greater when at its closest point than at its furthest point? Put a cross (☒) in the correct box.

1 / 25 ☐

1 / 5 ☐

5 ☐

25 ☒ ✓

Five times closer at 2.5 A.U. than at 12.5 A.U. The gravitational pull is therefore twenty-five times greater.

(1)

$$\vec{F}_{gravitation} = \frac{G M_{\odot} \times m_{comet}}{(\text{distance of the comet})^2}$$

14.(d) Away from the sun — see my diagram in 14 (c)

(e) Comets leave a wake of debris ⟶ meteor stream, as the Earth intercepts the shower.

Meteors tend to become visible around 40 km to 50 km ("often higher) above the surface of the Earth. In general, they have the diameter (roughly) of a grain of rice, arriving around 11 km s^{-1} — the "escape velocity" of the Earth.

It is a quantum effect which causes them to glow, not heat due to friction: the air is too tenuous at that height.

What we observe is the ionization trail. Clearly, the meteor itself is far too small to see. In my opinion, the most remarkable feature of a so-called "shooting star" is the quietness — not a sound as the meteor streaks across the sky. I remember, at the age of around six, being completely puzzled by the silence. I was disappointed when my Dad had no explanation...

15. The photograph shows the Helix Nebula, a typical planetary nebula.

Image courtesy of NASA

(a) What stage in the evolution of a star does a planetary nebula represent?

The end of the evolutionary process

(1)

(b) What type of star is at the centre of a planetary nebula?

A White Dwarf

(1)

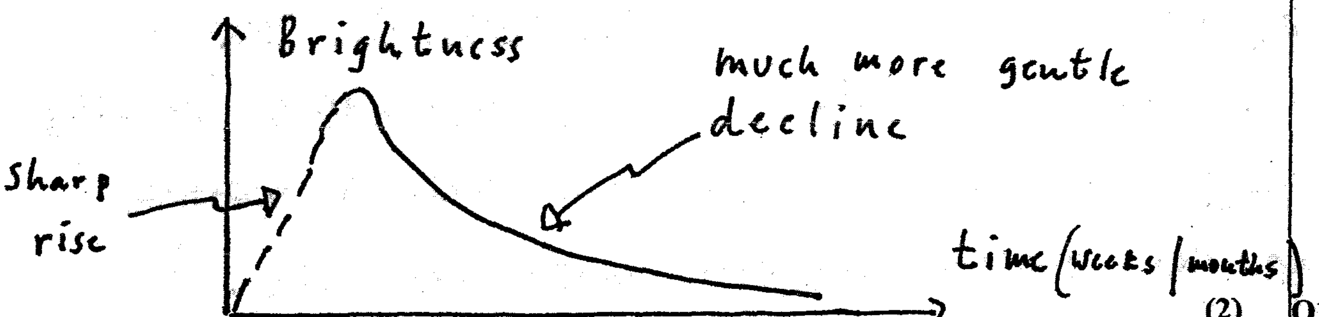
(c) The shell of gas in the planetary nebula is expanding. Describe how an astronomer might demonstrate that the shell is expanding.

Obtain a spectrum of the shell.
Observe the blue Doppler Shift (of approach)
in the spectral lines. [Christian Johann Doppler: 1803–1853, Austrian mathematician and physicist].
This effect demonstrated the rotation of the Sun in 1871.

JF[2]

(3)

(d) Sketch the light curve of a supernova.



(2)

Q15

(Total 7 marks)

JF^2

Perhaps the best-known example of a supernova is now referred to as the "Crab Nebula." This is thought to be the result of a supernova explosion, noted by Chinese astronomers over nine hundred years ago. The expansion of the nebula has been accelerating since then.

The nebula is expanding at a rate of about 1400 km s^{-1}, with an angular expansion of around 0·15" (arc seconds) yr^{-1}

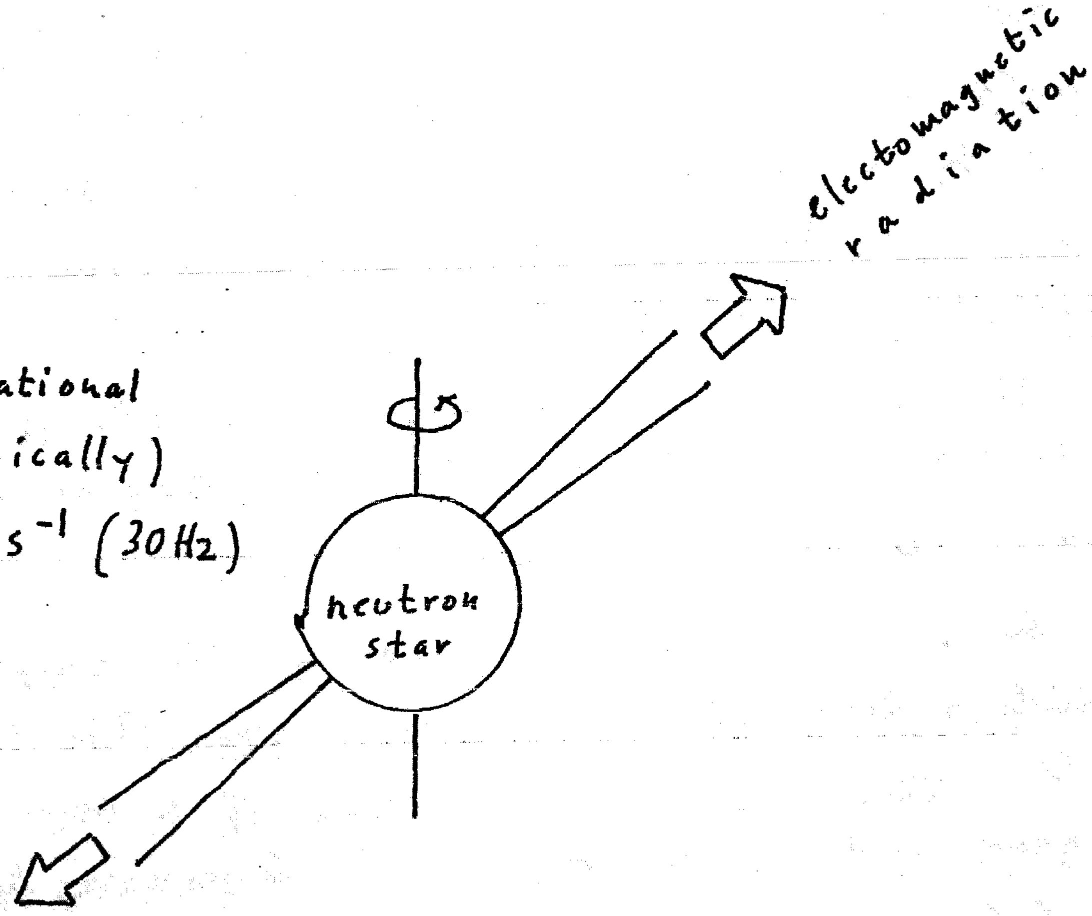
Such an explosion leads to the complete disintegration of the original star. The end result might be the production of a supernova remnant and a neutron star. Supernovae type I are believed to be caused by the collapse of a White Dwarf which accretes too much material to support itself; supernovae type II are thought to be massive stars reaching the end of their "lives." The explosion that produced the Crab Nebula, and pulsar, is believed to be a supernova type II.

The Crab Nebula is now thought to be a rapidly-rotating neutron star.

——D

angular spread

A high rotational speed (typically) $f = 30\ s^{-1}$ (30 Hz)



The best description of pulsars suggest that their magnetic axes are offset from their spin axes, just as the magnetic poles of the Earth are offset from the geographical poles.

It is thought that the radiation from the neutron star originates from the magnetic poles. So, as it spins around its axis of rotation, beams of radiation sweep around the sky. The two "peaks" which we see each cycle from the Crab pulsar presumably originate one from each magnetic pole of the neutron star. The fact that both beams are detected suggests that there are some asymmetries involved and the two beams might not be diametrically opposed, or have the same angular spread.

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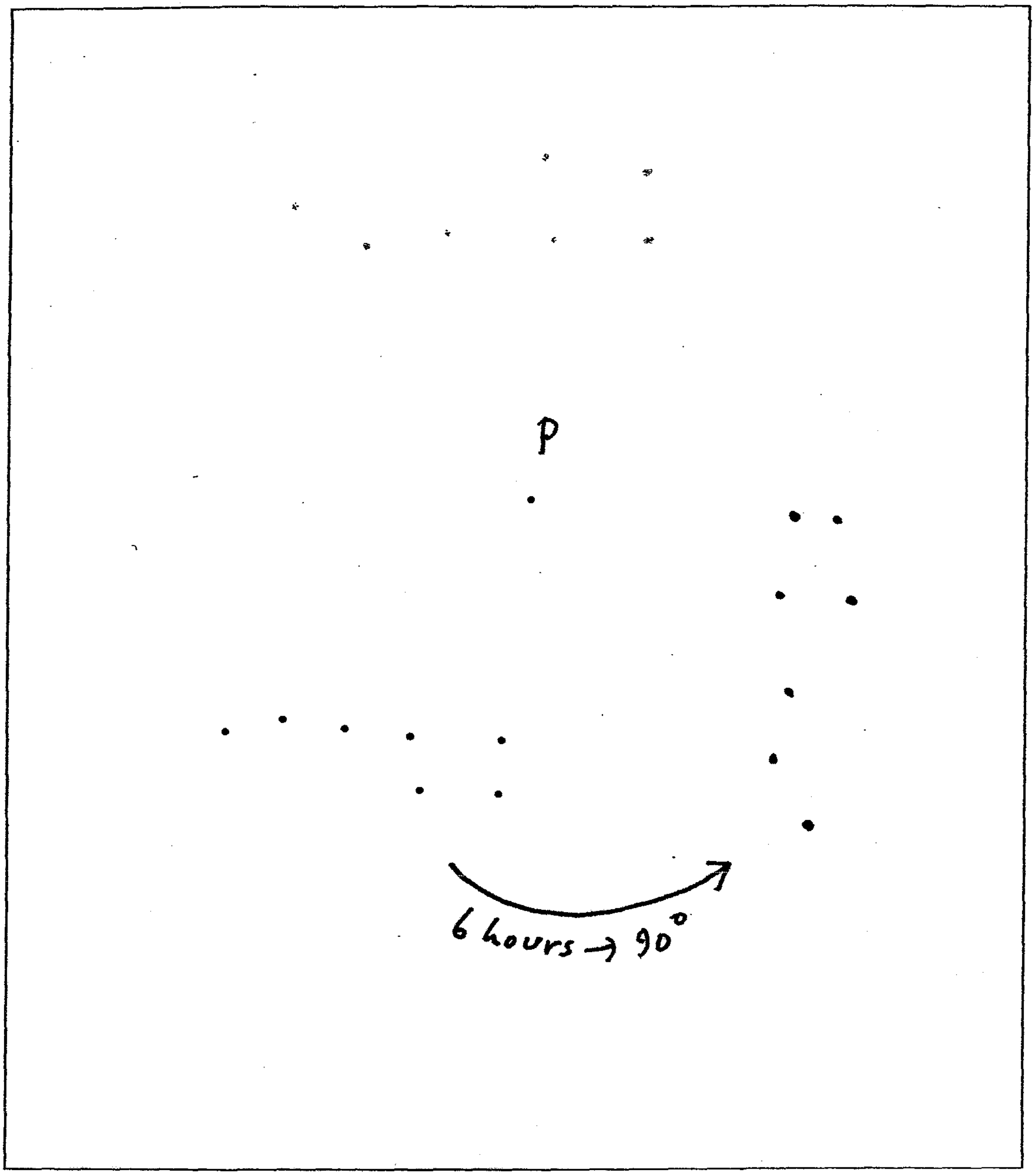
6. A student observed part of the sky at midnight in December from a latitude of 55 °N. She sketched what she saw.



(a) One of the stars is Polaris.

(i) Indicate this star on the diagram (use the letter **P**).

(ii) What is the name of the group of stars shown?

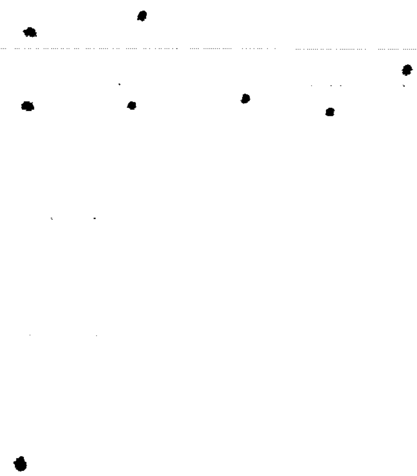
The Plough

(iii) Draw, on the diagram, how this group of stars would appear 6 hours later.

The Plough is circumpolar. That is, it revolves around Polaris in 24 hours. During 6 hours, it would complete one-quarter of a revolution. **(3)**

Leave blank

(b) If the student observed the same part of the sky at midnight in June, sketch what she would see.



(1)

Leave blank

(c) Explain why the student would never be able to observe a planet in this part of the sky. Planets are confined close to the plane of the solar system (the ecliptic) and are, therefore, visible generally in the south.

(2)

(d) Explain why the student could not observe Orion in June.

Apart from the circumpolar ones, the constellations are seasonal. Orion is a winter constellation, which means that it lies in the direction of the Sun during the summer

(2)

Q16

(Total 8 marks)

17. (a) On 26 December, a student at Greenwich observed that the star Betelgeuse crossed his meridian at 16:48 GMT.

(i) In which direction was the student looking?

South

(1)

(ii) How many days later would Betelgeuse cross the student's meridian at 16:36 GMT?

Three

(1)

(iii) A second student observed Betelgeuse on 26 December from a longitude of 2.0°W. At what time (GMT) would this student observe Betelgeuse crossing his meridian?

Two degrees corresponds to eight minutes (later)

16:48 + eight minutes = 16:56

(2)

(b) Explain the need for time zones.

So that noon, dawn, sunset, sunrise have similar local times, irrespective of where we are in the World.

(2)

Q17

(Total 6 marks)

See also my answer to number (12) on the 2006 paper

18 (a)

1. The contribution to the observed "background radiation" which has no identifiable stellar or galactic source and which occupies the wavelength range from about 0·1 mm to 0·1m
2. Characterized by a black-body spectrum corresponding to a temperature of $(2{\cdot}725 \pm 0{\cdot}002)$K.
3. Has a highly isotropic distribution.

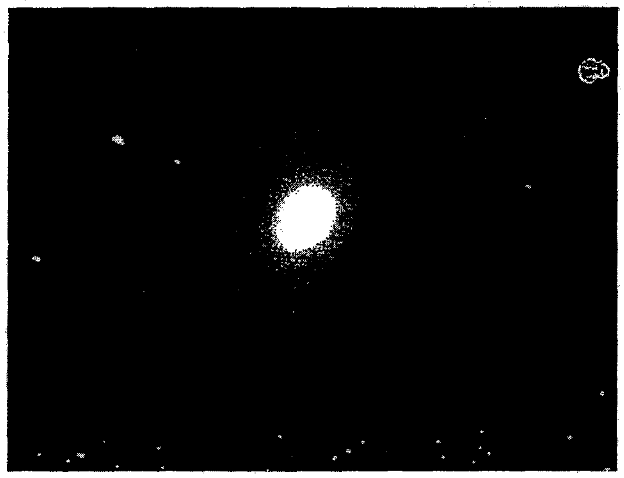
(b) 1. The distribution of radio "brightness" across the Sun at various wavelengths.
2. Large-scale structure of the Milky Way Galaxy.
3. The angular momenta of radio sources.
4. The "Radio Sky" at different wavelengths.
5. Profile of 21-cm line radiation from Hydrogen in the Galactic plane.
6. The rotation of the Galaxy.
7. Positions of supernovae.
8. The measured velocities of meteors.
9. The Radio temperature of the Moon through one <u>lunation</u> (one lunar month).
10. The reflexion of radar pulses from the Moon.
11. Radio waves from Jupiter.
12. The large-scale distribution of galaxies (vital in the study of Cosmology).

There is something in the above list to suit all tastes. I suggest that you select <u>three</u> which most intrigue you...

For those of you who require even more examples... you must wait for your university course.

Leave blank

19. The image shows M82, a giant elliptical galaxy.



(a) Name **three** other types of galaxy.

1 Spiral

2 Irregular

3 Lenticular

(3)

(b) Another elliptical galaxy is 10 Mpc from the Earth and has an absolute magnitude of –20.4.

1 Mpc = 1 000 000 pc. Calculate the apparent magnitude of this galaxy.

Yes, I still hate this → Use the formula $M = m + 5 - 5 \lg d$ ← This is provided for the candidates who would have difficulty in using the inverse-square law.

m = apparent magnitude

M = Absolute Magnitude.

At 10pc, this other elliptical galaxy would have an Absolute Magnitude of -20·4.

⇒ 10 Mpc is one million times more distant.

∴ At its observed distance, it is $\frac{1}{(1000000)^2}$ times as bright

or $(1000000)^2$ times fainter

= 10^{12} times fainter

$\Delta B = 10^{12}$ → Using "$\Delta B = (2\cdot51)^{\Delta m}$"

Substituting: $10^{12} = (2\cdot51)^{\Delta m}$

Taking logs. to base 10 on both sides:

$\log_{10} 10^{12} = \Delta m \log_{10} 2\cdot5$ →

20.

(a) Arcturus is $5.26 \times 10^5 \times 34$ light minutes away from the Earth.

∴ The distance of Arcturus in Solar distances

$$= \frac{5.26 \times 34 \times 10^5}{8.3}$$

$$= \underline{2.2 \times 10^6}$$

These are unfamiliar units, I must say

(b) From the information provided,

1 pc ≈ 3.26 l.y.

∴ 460 pc ≈ $3.26 \text{ l.y.} (pc)^{-1} \times 460 \text{ pc}$

≈ <u>1500 years</u>

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* I have always encouraged you to work from first principles. Simply employing the "Distance Modulus" (as it is called) is contrary to this philosophy. Gentlemen, you <u>must</u> use which method is the better (and more accurate) for you.

19 (cont)

$$\Rightarrow \Delta m = \frac{\log_{10} 10^{12}}{\log_{10} 2.5}$$

$$= \frac{12}{0.4}$$

$$\therefore \underline{\Delta m = 30}$$

This means that, at 1Mpc, the galaxy is 30 magnitudes fainter

30 magnitudes fainter than −20.4 is −20.4 + 30

<u>= +9.6</u>

<u>or</u>

$-20.4 = m + 5 - 5 \log d$

There is zero Physics in this expression!

Rearranging:

$-20.4 + 5 \log d - 5 = m$

$\Rightarrow \underline{m = +9.6}$ *

(Please see above)